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Special Meeting, October 29, 1897.

President FRALEY in the Chair.

Present, 100 members.

The special meeting was held for the reception of communications on subjects of science.

Dr. Fridtjof Nansen, a recently elected member, was presented to the Chair, and took his seat.

Dr. Nansen presented a communication on "Some Results of the Norwegian Polar Expedition, 1893-96," which was discussed by Commodore Melville, Prof. Abbè, Prof. Heilprin and Mr. Amos Bonsall.

The reading of the rough minutes was dispensed with, and the Society was adjourned by the President.

SOME RESULTS OF THE NORWEGIAN POLAR EXPEDITION, 1893-96.

BY DR. FRIDTJOF NANSEN.

(Read October 29, 1897.)

Mr. President, Ladies and Gentlemen :—

First of all, I beg to thank you most heartily for the great honor the Society has shown me and the cordial welcome you have given me.

It is with some hesitation that I come to discuss the results of the exploration from which I returned last year. The material I brought back is not by far worked out, and it will take years before it can be properly studied, and before this is done perhaps I ought not to talk much about the results for fear of giving you wrong ideas. But in the meantime I would like to point out a few of the more important points in our discovery, and I propose to begin with the geographical discoveries.

The whole plan of the expedition was based on a theory concerning the currents, about which we knew very little before. I thought, for various reasons, that there was a constant drift of

the ice across the north polar region. I would especially refer here to some relics from the American ship *Jeannette*, which were found on the southwest coast of Greenland three years after the *Jeannette* was crushed and sank at a point northeast of the Siberian Islands. The question arose, How could these relics have come to the coast of Greenland? The only feasible explanation, in my opinion, was that first proposed by Prof. Mohn. The relics must have been drifted straight across the polar region to the north of Franz-Josef Land and Spitzbergen, then must have come southward by the east coast of Greenland, thence around Cape Farewell and northward along the southwest coast. (Dr. Nansen then taking his position by a chart pointed out the supposed course of the relics.) Here is a map of the polar region. The *Jeannette* was beset in the ice near the Wrangel Island, which was then believed to be a large land, extending northward. She was drifting for nearly two years in a northwesterly direction to a point about here (indicating), where she was crushed by the ice pressure and sunk; and, as you know, the gallant crew of that vessel had a desperate struggle to reach inhabited parts, and it is unnecessary here to touch upon the sad fate of most of them.

Three years later some relics were found down here (pointing to the southwest coast of Greenland) and the only explanation was that they must have drifted this way down (indicating). There was, however, other evidence that made me believe still more firmly in this constant drift across, and that was especially that drift timber is found on the Greenland coast, on the Spitzbergen coast and on various other lands in the Arctic regions, and that most of this drift timber proves, on examination, to have come from Siberia. The only explanation, in my opinion, is that this drift timber must have been carried to these shores by the floe-ice across the polar sea somewhere near the pole; although I must say that this opinion is against that of most authorities.

As a further proof I will mention a third evidence of great importance, and that was some mud that I found on the ice floes on the east coast of Greenland. This map does not show it, but Iceland would be about here (indicating) and there is a strait between Iceland and Greenland. In this strait I collected, in 1888, some specimens of mud, and by a microscopic examination of this mud it was found to contain many diatoms never found anywhere else in the world except near Bering's Strait. Some specimens collected

by the Swedish *Vega* expedition were examined by Prof. Cleve, who also examined my mud. He said "that the diatoms contained in the two samples of mud are perfectly alike, and are totally different from those contained in all other samples in the whole world." I thought it could not be explained in any other way but that there must be some connection between the two places, the ice carrying the mud to where this mud was found across the polar sea.

There were also other evidences that made me believe in this drift current. If this drift really existed, I thought it a simple thing to go with it; to build a ship strong enough to stand the pressure, push her into the ice and let her be carried along with it just as the *Jeannette* was. And that is what the expedition accomplished. As the expedition was therefore undertaken with the intention to drift with the ice, we could not expect that we would discover many new lands. My hope was to keep clear of the land, as that would stop our drifting and perhaps oblige us to leave the ship and travel over the ice. We were fortunate enough not to meet any land. We found only one vast extended sea in the north, which was very much deeper than we had expected.

Before we set out a good many authorities said that the reason why such a drift was impossible was because we would meet with much land in the north, and that the sea was shallow. So far as we knew it was shallow north of Asia. The greatest depth found by the *Jeannette* expedition was eighty fathoms. I also believed that this sea might be pretty shallow, but seeing that there was a deep sea north between Greenland and Spitzbergen, a sea extending up to 2600 fathoms in depth, the northern limits of which had not been found, and seeing at the same time that the depth increased with the progress of the *Jeannette* expedition, as it was carried to the north and east, I said it looks as though there should be some connection between the deepening of the sea to the north of where the *Jeannette* expedition met with disaster and this deep sea east of Greenland. I thought there might be some narrow channel or trough of deep sea across the polar region.

Great was my astonishment when I found a great depth as soon as we got north of the New Siberian Islands. All the way north from the Siberian coast there was a very shallow sea, only twenty or thirty fathoms deep, until at a certain point the depth suddenly increased and we could not reach the bottom with all the lines we had on board. We had to make new line and at last we found the bottom

at about 2000 fathoms, and we found the same deep basin along the whole route of the *Fram* across the polar region.

The question then arises, Of what extent is this sea? I did not find anywhere any indication that the sea grows shallow. We see it stretching from the south northward into the unknown. We also see it stretching eastward to the region north of the New Siberian Islands and we might expect it to extend much further eastward. When we look at the deep seas on the rest of the globe's surface we do not find anywhere such a long, narrow extension of very deep seas; and, therefore, the probability is that this sea is much broader than we had an opportunity of ascertaining. We may therefore say that we have established the fact that a great part of the polar region is an extended, deep sea, instead of the shallow sea that we believed in before. I think there cannot be much doubt that the whole of the polar region lying on the Asiatic and European side of the pole is one extended sea.

For this belief we have several reasons. First, as I have just mentioned, the depth of the polar sea indicates some extension of the sea to the north of the *Fram*'s course. But there are other evidences. It is evident that ice drifting in a sea where there is land in the neighborhood will be stopped in its drift as soon as it drifts in the direction of this land. Now, however, if there had been land anywhere in the neighborhood of our route it is evident that if the ice happened to drift in that direction it would have been stopped at once. But we never saw anything of the kind. The ice seemed to drift readily in almost every direction as the wind commenced to blow in that direction. The only direction in which the ice seemed to drift slowly and with some difficulty was backward in the direction from which we had come, and there we knew there was nothing but open sea. Very easily, say as soon as the southerly wind began to blow, the ice drifted toward the north, consequently there was no possibility of land being found anywhere near us in that direction.

There is another evidence which is even stronger, and that is the amount of floe-ice or polar ice floating southward through the channel between Spitzbergen and Greenland and especially along the eastern coast of Greenland.

When you look at the route of the *Fram* you see the drift going in this direction (indicating). She drifted to about this point (indicating), and then began to work herself out of the ice

by forcing herself forward with the help of her steam engine. If she had not done this she would, of course, have been drifted further in the same direction, and then she would as you see have been drifted southward along the east coast of Greenland, and might have drifted in that direction for a year more.

Thus you see there would have been a broad belt of drift ice drifting southward between the *Fram* and the coast itself. It is evident that this ice must have traveled by a route similar to that of the *Fram*, but that route had been to the north of the *Fram*'s. All this ice (indicating) must therefore come from an extended sea lying to the north of our route, and consequently there cannot be any land in that region stopping the drift. Thus, we have good reason to believe that the whole extent of this region on the European and Asiatic side of the pole is nothing but sea, perhaps with some small islands of no importance. In my opinion the pole itself is situated in the same extended deep sea.

This distribution of the land and water on the European side is, I think, the most important feature of the geographical discoveries made by us on the expedition. There might, of course, be found land on the American side of the polar region. It is not probable that we should just now happen to have found the northern limit of land on this side. Much still remains to be done by future expeditions in geographical exploration.

Before leaving the subject of geographical discoveries, I will briefly mention the extent of Franz-Josef Land. You know that the group of islands situated to the east of Spitzbergen, called Franz-Josef Land, was discovered by the Austrian Tegethoffs expedition in 1872-4. The expedition had only explored the southern coast of this land and made a dash northward through a narrow channel which was called Austria Sound. Afterward the English explorer Leigh-Smith came two summers to this land and discovered the more western part of its coast. The last time he came his ship was crushed and he spent the winter there and came back in boats the next year. The northern extension of this land was not at all known, and therefore it was believed by some authorities that this land was only the southern coast of a big continent extending poleward. I did not believe this; I believed that Franz-Josef Land was only a group of islands. Now with our discoveries and those of the English Jackson-Harmsworth expedition it is an established fact that Franz-Josef Land

is a group of very small islands. We came southward here (indicating) and we saw there was no land of importance to the north. The island we first met with was situated in $81^{\circ} 38''$ north latitude. We traveled along the north coast here (indicating), and now the English expedition has this spring traveled along the northwest coast of these islands here (indicating) and found that there was nothing but a comparatively small island which approximates the most western point of this map. Consequently we know pretty nearly the whole extent of Franz-Josef Land. We want to know its extent toward the east and it is hoped that some expedition not far in the future will settle that.

While I have mentioned the geographical results of the expedition, I should mention the geological results also, but will not detain you long with them. There is one important geological discovery which we made, and that is the evidence we found of a glacial epoch in Siberia. As you certainly know, the whole of northern Europe and the northern parts of North America have had at least one glacial age, during which they were covered with an extensive ice cover as Greenland is at the present time. It was, however, generally believed that Siberia and the whole of northern Asia had had no glacial age, as there were no marks indicating an ice-cover in those countries. During our voyage along the Siberian coast I had an opportunity of visiting the coast at several places, and everywhere I found signs that there had been at one time a glacial covering, an ice mantle over the whole country. We found the coast here pretty much cut up. It did not look as it appears on this map, but looked more like the western coast of Alaska, and more like the coast of Norway.

Outside of the coast there was a belt of islands which we find only along the coasts of lands which have once been covered with an ice cap. This is but an indication that something of the same kind must also once have existed in Siberia. But I found more certain proofs that such had been the case. In one place I saw the rock scratched with glacial striæ and marks, which is a certain evidence that glaciers have once covered that country. In another place I found ground moraines covered with big erratic blocks of various forms, and there is, in my opinion, no explanation of these blocks being there except that they have been carried by glaciers similar to what we know have been in Europe and America.

I have already mentioned some of the evidences on which I

founded my theory about the drift of ice across the polar region. I have mentioned that the expedition was accomplished in the way it was planned, and thus the theory was proved to be fairly correct. The expedition has, however, given us a great deal of information which enables us to form a much clearer and better idea of this drift of ice across the polar region than we could have had before. We have had plenty of experience, and have made many observations of how this ice is constantly being drifted from one side of this polar region to the other. What causes this drifting? The drift is for the most part caused by the prevailing winds. The data collected have not been calculated yet, but so far as I can now say the direction of the prevailing winds was pretty nearly the same as the prevailing drifts. Perhaps they do not, however, quite coincide, as I believe there are some other factors which also help to decide the final drift of the ice.

The prevailing winds in this region during the whole year go from this Siberian side (indicating) toward the Atlantic sea, and consequently sweep the whole expanse of ice cover out into the Atlantic sea. That is the main feature of this drift. Of course there are many variations, many periods of drift during the year. At some periods the drift is more rapid. At other times the drift stops, or even goes in the opposite direction. But as a rule the best period for the drift to go in the direction we wanted was the winter and spring, and the worst period, generally, was the late summer and autumn.

I may mention here that the route you see on this map¹ is very much simplified. If we had it marked down as it really was it would not be possible to understand it; it would be so complicated that you would not know one drift from another. During the first autumn we had a drift backward, and were drifted southeast into the shallow sea and toward the New Siberian Islands again. Then the winter came and we were pushed forward until the middle of June, and then came another bad period and we were pushed backward. Then it began to drift onward again until the next year; then there was a stop again during the summer. Then there was a more favorable drift during the winter again until the Fram worked her way out of the ice to the north of Spitzbergen.

You will understand that we are now able to form pretty nearly a complete picture of the motion of this ice in the polar sea. You

¹ An enlarged drawing of a map given in "Farthest North."

see how it is carried across the polar regions from the Siberian side toward the opening between Spitzbergen and Greenland, and also toward the channel between the islands in the North American archipelago. As, however, there is no such gap between these islands as between Spitzbergen and Greenland, the ice there seems to be very much blocked, and is stopped for years and gets very much thicker than on the East Greenland and Spitzbergen side. By snow being heaped upon it year after year it forms striæ similar to what we find in glacial ice; it is what has been called the paleocrystic ice by the English and American explorers.

You understand that our expedition has removed that extended massive and immovable ice-cap, or mantle, which so many explorers thought covered the polar region. Instead we have found a deep sea covered with a comparatively thin layer of ice in constant motion from one side to the other, being one link of the eternal circulation of the ocean.

We had a very good opportunity to study the formation of this ice. I shall mention here only the growth of it by the frost. A good many people, I dare say, believe that the ice in the north goes on growing forever, and that it gets thicker and thicker every year it remains there. That is, to some extent, the case; but it is not quite so simple, and the growth is not so quick as one would generally imagine. In the beginning, as long as the ice is thin, it grows very rapidly. It was measured at certain intervals during the whole expedition. Ice formed in November of the first year, 1893, had in April, 1894, attained a thickness of seven and a half feet. On June 9, it was eight feet three inches thick. That is about the growth of one year. In some parts it was nine feet thick. In the last month of summer and in the autumn it melted a little. At the beginning of the winter, in September, the same floe was about six and a half feet thick. Then the growth began again very slowly, and in May of the next summer, 1895, the same ice had become nine feet ten inches thick. You see it does not increase very much after the first year. The next year another floe was measured. At the beginning of the winter, in November, it was eleven feet thick. At the end of that winter, in May, 1896, it had reached a thickness of thirteen feet six inches. This ice was about three or four years old. The most of the ice that drifts across that region will not grow much thicker directly by freezing, as it is carried across the polar sea, at most, in five years.

By the pressures the ice is, however, piled up to very much greater thicknesses, and ridges and hummocks are formed, the height of which may amount to twenty feet or even more above the water. The highest hummock I ever measured was twenty-three feet high, so far as I remember. I saw a few which I estimated to be about thirty feet high. These hummocks will freeze solid and will last for years. I might mention one which was formed near the Fram in January of our first year, which followed the Fram during the whole time of the drift. This hummock has probably drifted on southward along the East Greenland coast. The ice floes are crushed easily, but these hummocks require much more force to crush them. They will stay together and be the last remnants of the ice to be carried around Cape Farewell and the west coast of Greenland.

The cause of these ice pressures has already been referred to in the accounts of previous expeditions. It is a fact, which has often been observed by various explorers, that the pressures are to some extent caused by the tidal currents. Our observations showed that at the margins, near the outer edge of the polar ice-pack, where there is an open sea to the south, the ice pressure is almost solely caused by the tidal currents. The pressures were there often so regular in their occurrence that we could say beforehand when the ice pressures would occur. We knew that they would come with the spring tide, the heaviest ones a little after new moon, and another period with less heavier pressures about full moon. The pressures would at these periods generally occur twice in twenty-four hours. Then the ship would often be lifted a good many feet out of the water, while in the intervals the openings in the ice would widen out and the ship would be floating in a broad, open channel.

In the interior of the polar ice these tidal currents do not seem to have much influence on the pressures. I could not discover any regularity in them there. The pressures seemed to be caused mostly by the changing winds. It is evident that when the wind suddenly changes, especially to the opposite direction to that from which it has been blowing for some time, immense pressures must arise. The great body of ice is moving on, while in front the ice is moving against it. We had a very severe nip on such an occasion about New Year's day, 1895. I dare say it was the heaviest ice pressure any ship has ever been exposed to, and that was

in the middle of winter when the ship was frozen fast in her ice berth.

These ice pressures which form the hummocks that I have spoken of, and which make the ice so much thicker in some places than in others, give room for cracks and open water lanes in which new ice is formed. Thus one must not think of the polar sea as being covered with one even layer of ice. We find floes of all thicknesses from this newly formed ice on the lanes up to the big hummocks which are very deep.

There is one important feature in our discoveries about which I shall say a few words, and that is the temperature of the sea. As is well known, the temperature of the deep sea all over the world is very low. It is not many degrees above the freezing point. In the northern part of the Atlantic ocean the bottom, and in fact the whole sea on the Greenland side, is filled with water two or three degrees below the freezing point. The temperature is about 29.4° Fahrenheit through nearly the entire depth from the surface down to the bottom. Of course as far as the Gulf stream runs north the surface is very much warmer. As the polar sea sends southward such a cold current, filling the whole depth of the North Atlantic, you would naturally expect the whole polar sea to be filled with such cold water. But such is not the case. We found that from 100 fathoms under the surface of the polar sea down to the bottom the water is warmer than we find it in the depth of the North Atlantic ocean. I will give you a few of the observed temperatures. The surface of the polar sea is covered with a layer of water of comparatively low salinity, and is very cold. But when you penetrate down through this layer you find that the temperature begins to rise. At the surface you find the temperature -1.5° Centigrade, which means 29.3° Fahrenheit. But at a depth of 110 fathoms you suddenly come on warm water, the temperature of which would be as much as 32.9° or even 33.4° Fahrenheit, which you see is very much warmer than you would expect or than you find in the deep sea in the North Atlantic ocean.

At a greater depth the temperature varied somewhat, but remained about the same to a depth of 220 to 270 fathoms, after which it sank slowly toward the depths, though without sinking to the cold temperature of surface water. Near the bottom it again rose quite slowly. These conditions were fairly uniform in that part of the sea over which we traveled and where investigations were made.

It may seem rather striking that the sea should be so warm in the depths and so cold on the surface. The reason is natural. I may say first that the cold surface layer of water was fresher than the lower warm layers. The deeper water had a high salinity very much like the Atlantic water. That is the reason why this warm water is heavier than the cold water and keeps below. All this salt and comparatively warm water runs into the polar sea from the Atlantic ocean, filling the whole depth of the polar basin, while its surface water to some extent is mixed up with the fresh water running in from the American and Siberian rivers.

The Atlantic water is slowly cooled down and is gradually, to some extent, mixed with the fresher water of the surface and is then again carried out into the Atlantic ocean as water with less salinity than the Atlantic water and much colder; and on that account is heavier and sinks and fills the bottom of the sea. What is the result of these conditions? The result is that the fresh water floating on the top of the salt warm water protects the ice to some extent from the influence of the heat which is carried into the polar sea by the Atlantic water. It allows that ice to grow slowly year after year. If this fresh water had not existed the Atlantic water would come to the surface in the polar sea, and this covering of ice would consequently be very much thinner.

If we look backward through the ages and ask what the result would have been if the geographical distribution of the land and water were a little different from what it is to-day, what result would we expect? What would the result be if we were to shut up the whole polar basin, not allowing this warm water to flow into it and not allowing the ice and the cold water to float out of this polar sea? If we had a bridge of land passing from Greenland to Iceland and across to the Faroe and Shetland Islands, uniting Scotland and England with Greenland, and consequently closing up the whole entrance to the polar sea, what would be the result?

The result would be that no warm water would be carried from the south to the polar region; the ice would be allowed to block up there year after year and would not be allowed to drift across and out, and by and by the whole polar sea would necessarily be covered with a very much thicker layer of ice and snow than at present. This layer would at last have no more motion and the thickness of the ice would allow the temperature to fall during the winter on account of the radiation of heat from the surface. This

would produce a cooling down of the polar region to a much greater extent than exists to-day.

Consequently we would have in the north a colder climate, and we would at the same time have a warmer climate in the south, because the ocean would not be cooled down by the northern ice, and it would be prevented from giving off a good deal of its heat to the polar region. That might to some extent explain a colder climate in the north and a warmer climate in the south, but I do not think it would be sufficient to explain the glacial periods. It gives us, however, some idea, or some factor that would explain the changes of climate on the surface of the globe.

You might ask what would be the result if we could open out the entrance to the polar sea and let more warm water flow into it. If, for instance, the Bering's Strait could be made much wider and deeper than at present, so that the warm Japanese current, the Kurosiwo, could run into the polar sea, its temperature would then, of course, be very much higher than at present. It would still be covered by a layer of fresher water from the rivers flowing out of Siberia and America, but the thickness of the ice would be less than at present. If we, however, could let the rivers of Siberia flow in some other direction, not going into the polar sea, but somewhere else, so that the polar sea would not be covered by such a layer of fresh and cold water, what would be the result? The warmer water would then come up to the surface, the ice would necessarily be thinner, we would get much more open sea in the north, and to some extent the climate would be milder. At the same time much more cold water would run out of the polar sea into the Pacific and Atlantic oceans, and would cool down the temperatures in those latitudes.

I do not think this explanation is sufficient to account for the much warmer climate in the north when we, for example, had a sub-tropical climate in Greenland and Spitzbergen. At the same time it may give you some idea of what such changes in the distribution of the land and water would result in.

I will not go further into these very difficult questions. I just mention this to show you what glimpses polar exploration might give us into the conditions existing during other ages of the earth. This is only one side of the many results which polar explorers have brought back from the polar regions. They have to a great extent enlarged the knowledge of humanity. They have made it possible

for us to form ideas of the past history of the globe which we would not have been able to form had not man gone out to explore these regions.

I hope to see new expeditions start soon again for these regions, and I trust that especially this great nation will take an important part in them. We know from what you have accomplished in the past that you will be able to achieve great results to the benefit of the nation and to the benefit of humanity.

COMMODORE GEORGE W. MELVILLE :

It is with a great deal of diffidence that I arise to speak at all in discussion of so clever a discourse as that of Dr. Nansen, much less to criticise it, for my experience in three different Arctic voyages, in different Arctic seas, has taught me that only those who are in the same field at about the same period can have the requisite information to undertake a critical discussion. Moreover, Dr. Nansen's experience with respect to ice conditions, its formation, drift and other phenomena, so fully agrees with my own in the *Jeannette*, that there is no room for argument.

However, my sojourn of twenty-two months in a drifting pack of no mean proportions, extending from the Pole south to 70° , emboldens me to speak of some experiences, second only to those of Dr. Nansen and of Weyprecht and Payer of the *Tegethoff* expedition of 1871 to 1874.

The *Jeannette*, Capt. De Long, U. S. N., was boldly pushed into the ice in latitude $71^{\circ} 35' \text{ N.}$, 175° W. , as we then believed the theory of Dr. Petermann, the celebrated German geographer, that Wrangel Island might be of continental proportions, extending to the northward and eastward toward the Pole, and possibly extending so far to the eastward as to overlap the northern part of Greenland. It was thought to be what some explorers had supposed to be land seen to the northward of the Spitzbergen, and extending as far to the eastward as the archipelago formed by the Spitzbergen on the west and Franz-Josef Land on the east.

It took us but a few days to prove that Wrangel Land was only an insignificant island, as we drifted across its northern face, at times in as little as thirteen fathoms of water ; and at times as close as fifteen or twenty miles to its northern shores.

It is needless to state that drifting in a heaving pack in so shallow

a sea was most hazardous, the underrunning and overrunning of the floes causing them to telescope and rise to heights at times approaching 100 feet.

After our ship was solidly frozen in, she was never again released until she was finally crushed on June 12, 1881, after we had drifted twenty-two months in a zigzag course, many times lapping and crossing and recrossing our track. The resultant of our drift was north, 45° west true, distance 1300 miles, when our floe broke up, and the ship was crushed, in latitude $77^{\circ} 15' N.$, $155^{\circ} E.$, leaving us 500 miles in a bee line from the nearest point of succor, the mouth of the Lena river, Siberia. We were left on the ice, thirty-three officers and men, with seven on the sick list, and with the disheartening prospect of hauling our baggage an indefinite distance to clear water. It consisted of eight pieces, giving each man fit for duty a load of 290 pounds to haul.

Just here, let me call attention to the very important fact that the Jeannette expedition is the first on record where such a long imprisonment in the Arctic pack was not accompanied by scurvy. The Lady Franklin Bay expedition, under the command of Lieut. (now General) A. W. Greeley, U. S. A., was the second up to the date of our wreck which had escaped the dread scourge. Our good fortune, so different from the experience of previous expeditions, can be clearly traced to good food, distilled water, good sanitary conditions, a light, though healthy diet, and abundant outdoor exercise, not of a laborious or wearying nature, every day in the year.

You will, I am sure, pardon me for introducing a few facts of the drift of the Jeannette, as leading up to the drift of the Fram, for Dr. Nansen put his ship into the ice to commence his drift about where the Jeannette let go, though a little farther to the westward. In other words, the Fram finished the drift that was commenced and prosecuted by the Jeannette involuntarily, for our intent was to go to the northward and eastward. But, after being beset in the pack, and drifting across the north face of Wrangel Land, we were pretty sure that there was no possible retracing of our course, unless, by a swirl or turn of the floe, we might be cast out on the coast of Siberia, as the whaleship Mount Wollaston and others had been, which were visited by the native Tschuckchees and found abandoned.

As the cartographer of our expedition, I was directed to make a circumpolar chart showing every known current that had been laid down by Arctic explorers, from the time of Barents and Wil-

loughby to date. We were fortunate in having a very extensive Arctic library on board, and, as the discussion of Arctic literature and the formulation of theories and conjectures were among our pleasantest ways of passing time, you can well imagine that, with eight intelligent readers in our cabin mess, it was not long before I had a chart with hundreds of arrows denoting currents as laid down by voyagers for more than 300 years. It was remarkable how plainly they pointed to the fact that, if our ship should hold together and our provisions last, we should drift out either by way of Franz-Josef Land and Nova Zembla, or, taking the northern cant across the north face of Franz-Josef Land, between the Spitzbergen and east coast of Greenland. That was as well understood and believed by the officers of our ship as it is to-day proved by Dr. Nansen.

In addition to what we learned from our drift chart, we also knew that drift wood covered the east side of the Spitzbergen, Franz-Joseph Land, and even the northeast coast of Nova Zembla, where grand old Barents wintered, and it was certain that this was brought by the great Siberian rivers discharging into the Arctic ocean. These facts had all been established before our time, but none of us then supposed for a moment, nor do I now believe, that this débris would drift across the North Pole. In fact, I have not believed hitherto that it ever drifted beyond 85°, but Dr. Nansen and the drift of the *Fram* have demonstrated that it has drifted north of 86°. So I must concede that latitude, at least, as possible for drift wood to reach.

There were, however, two great "ifs" in the way of our accomplishing this long drift: Could our ship hold together; would our provisions hold out? We had pumped our ship night and day for twenty-two months, at first by hand and steam power, afterward by a wind-mill that was extemporized on board ship, supplemented by hand power, or steam, as the emergency arose. The merry "chug" of the pump night and day, for twenty-two months, never ceased. Our game in the far north had become scarce, and we had not added much to our larder beyond a few seals, walrus and bears we had taken in the early part of our drift, in the spring of 1880.

After many consultations about the situation by the officers of the ship, and a close account of the provision list, it became manifest that our provisions would be exhausted before January, 1882. So, the question was whether we should abandon our ship in the spring

of 1881, or the fall of the same year. As seamen, loyal to our ship and duty, we decided to remain by the ship as long as possible, though sober judgment taught us that the proper time to abandon the ship was in the spring, which would give us mild weather and summer game to assist us on our retreat. At that time, we were nearly due north of the New Siberian Islands, which seemed like stepping stones toward the Lena river and the coast of Siberia.

The problem was solved for us by the breaking up of the floe, which, in time, crushed our ship; and, amidst the crashing and grinding of the poor old ribs of our good ship, we were cast out, Cæsar-like, from the bowels of our good mother Jeannette, who had sheltered us and kept us warm all these months.

At this very time we were making our most rapid drift to the northward and westward, and it was impressed upon us in a most startling and disheartening way. The Jeannette was crushed and sank in latitude $77^{\circ} 15' N.$, longitude $155^{\circ} E.$; after marching southward twenty-one days, we found ourselves in latitude $77^{\circ} 36' N.$, longitude $153^{\circ} E.$, or actually *twenty-eight miles northwest of where we had started* and at the most northerly point of our voyage. This rapid drift is the key to the situation pointed out to our good friend, Dr. Nansen, who had the sagacity to seize the idea and to originate the theory that has led to his great success.

As I have said, our retreat lay directly south, about five hundred miles in a straight line. At the start we had sixty days' provisions, allowing one and a half pounds per man per day. Most of our dogs had died during the first winter, and of the remainder we shot all but eleven good ones, which, however, rendered very little service, eating nearly as much as a man and doing about one-tenth as much work, so that we finally shot them also.

Thus we journeyed, dragging our boats and provisions on sledges over the broken floe, and finally taking to the boats to cross the open sea to the Siberian coast. It was the stormy fall season of gales, ice and snow. Our small open boats were often in danger of foundering, and in the fiercest of the gales Lieut. Chipp's boat was swamped, drowning him and his seven men.

The other two boats, those of Captain De Long and myself, succeeded in reaching land, although one hundred and fifty miles apart, thus ending our long retreat of one hundred and ten days. De Long and all but two of his men perished of cold and starvation. My crew of eleven all told were more fortunate, all being saved,

although one died of smallpox in Siberia on the way home. The total loss was thus sixty-six per cent. of the personnel of the expedition, and of the original survivors there are only six now alive.

Now, as regards our drift. It was quite evident that, for the first eighteen months at least, our drift was caused by the fierce southeasterly gales that drove the pack up into the northwest. We can conceive the effect of the innumerable hummocks of ice, like millions of sails set to catch the breeze. After the subsidence of each gale, we took a rapid setback drift to the southeast. In fact, in the spring of 1880, after our first winter in the pack, we were driven back in sight of Wrangel Land to about the place where we were first beset, which accords with Dr. Nansen's experience.

Dr. Nansen found a deep sea to the northward and westward of the line of our drift, which is the exact opposite of our experience in the part of the ocean we traversed. Although soundings were taken every day at noon, they never but once showed more than from thirteen to thirty-six fathoms. Even this greatest depth was only eighty fathoms, which occurred at the most northern point of our drift during the winter of 1880.

I had a theory of an ice cap at the Pole (which, by the way, our good friend, Dr. Nansen, has very materially shaken) extending down to about 85° , against which I believed the drifting pack impinged. Between this supposed ice cap and the drifting pack, in the shallow sea in which we were drifting, I conceived a canal of comparatively deep water, which my messmates in derision called "Melville's Canal." It is needless to say, however, that I was pleased, as were also my messmates, to find that we were on the edge of "Melville's Canal" when we got a cast of the lead in eighty fathoms of water, and they conceded that my theory of a deep canal might be correct, so that, in our theories at least, "Melville's Canal" had a recognized standing.

Unfortunately, after the southeasterly gales had ceased to blow, we were rapidly drifted back again by the receding ice, and never again got far enough north to find the deep water where currents alone can run. It is impossible for any geographer to conceive of a natural sea current in a shallow sea of thirty fathoms. Local currents, it is true, may be caused by wind or tide, if there is any; or by the outflow of great rivers, but a natural current of inlet and outlet, caused by the heated or chilled waters, such as the mighty Gulf Stream, or the Kuro Siwo of Japan, can only run and be

maintained in water whose depth is measured in hundreds of fathoms. Such seas we did not find. Hence, my theory of wind currents in a shallow sea. Another fact of our drift is that our floe was continually swinging around, not always in the same direction, as our ship's head pointed to every point of the compass, though frozen solidly into the moving pack, demonstrating the fact that the great floe itself was in a "swirl." Dr. Nansen was more fortunate in early striking "Melville's Canal," where the water was deep enough to permit ocean currents to run.

Now, as regards the shallow sea over which the Jeannette drifted: Is this shallow sea caused entirely by the silt of the great northern rivers, or is it partly caused by the erosion of the land? The islands that extend all the way from the Lena Delta to "Bennette," "Jeannette" and "Henrietta," like so many stepping stones from the mainland toward the Pole, were, in my belief, at no very distant period, part of the mainland of Siberia. They are daily being eroded by the drifting ice pack; and, in time, nothing but the bare rocks will remain of these islands.

During our short stay on these islands, while on our march to the south, and while we were in the Lena Delta, the land was not making, but the daily evidence of the constant washing away by sea and ice floe, or melting snow, and occasional rain, showed that the islands were being denuded and eroded away.

I saw, on the banks of the Lena Delta, immense trunks of trees, with roots attached, that had apparently fallen *in situ*. Forty feet above the bed of the river, these lands were gradually washing away. These lands and the islands of the Arctic sea still show the remains of the mammoth which, without doubt, was a native of the mainland, and of the islands when they were part of the mainland. We found remains—tusks and teeth of the mammoth—as far north as Bennett Island, and, I doubt not, had time sufficed, similar remains would have been found on the other islands visited by the Jeannette.

I have thus digressed, gentlemen, from the main question of Dr. Nansen's drift, in order to justify the theory of a shallow sea more than 1500 miles in extent, east and west, though perhaps local in its northerly extension.

And now that Dr. Nansen has made the most magnificent drift on record, attained the highest latitude known to man, and made the most fortunate and masterly retreat, let us say, "Well done,

Nansen!" and let us plan the next possible drift from the east toward the west to make a high northern latitude, reaching, if possible, within marching distance of the Pole.

If Dr. Nansen is correct in his conjecture that we have deep water and broken ice, with open "polynias" all the way to the Pole, and, if my theory of a solid ice cap at the Pole (like an inverted saucer) is wrong, let us theorize a little further, and seek the best place to put a ship in the pack for such a drift as is contemplated. Let us see where our ship, if she holds together (which is doubtful), or if not crushed (possibly being buried in the overlapping and underrunning floes), let us conjecture, I say, the best place to put the ship in the pack for such a drift.

Dr. Nansen took several months to proceed from Norway, along the coast of Siberia, toward the river Alaneck, before he pushed north to take up the drift about where the Jeannette let go and sank in thirty-four fathoms of water, thus losing valuable time after leaving any source of supplies.

We must get north as rapidly as possible after leaving our last depot of provisions, so that if Dr. Nansen's theory of the Arctic ocean currents and of the ice conditions toward the Pole be correct, I believe that the proper place to put a ship in the ice will be through Bering strait. We should keep along the east edge of the pack in about longitude 165° W., attaining the highest possible latitude, and westerly longitude, culminating together. Then we should push the ship into the pack as far as possible to the northward and westward, and await the fulfillment of the prophecy of one of the jolly whalers I met at San Francisco. He said: "Melville, push her into the ice at about the point I have mentioned, and you will either go to the Pole or to hell, and I believe the chances are about even." I can't agree with my whale-fisher friend about the hell part of the business, for true philosophers have a right to disagree about that. I do believe, however, from the information we have gained from the drift of the Jeannette and of the Fram, that vessels of any kind, such as casks or driftwood, will come out by way of the Spitzbergen—though not necessarily across the Pole. The only reason for sending in ships and men is that there may be observers to make a daily record of events, and of phenomena, such as latitude, longitude, soundings, daily drift, dredging the ocean's bottom if possible; in fact, recording all the phenomena proper on such an expedition. But for this, I say, a

hundred oaken casks, properly numbered, made after the manner of a beer keg of twenty gallons capacity, properly hooped, and the ends extended out to complete a parabolic spindle, would demonstrate the drift. At the end of four or five years, we might begin to look for the beer kegs between the Spitzbergen and Greenland. And now, as regards the work of our honored guest this afternoon:

His is the honor to have reached the "Farthest North," the *Ultima Thule*, that has defied the best blood and brains for three centuries. He it was who conceived the grand thought of making that most perilous drift, though he knew not how long it might last, nor whether his good ship and ship's company would ever drift out of the terrible unknown sea of ice and snow. His was the honor—after waiting months and years for the slow drift, and becoming impatient of the gods of ice and snow—to break away from the good ship in order to add a few more miles to his northern journey; and, taking his life in his hands, with but one solitary human companion, to make the long and dreary march to Franz-Josef Land. And to what purpose? That we, the eager, driving, working world, might have that knowledge which is power, wealth and happiness.

And let me ask my hearers this afternoon, What better school of heroic endeavor for our lusty youth than the Arctic ocean? There, amidst the silence of the eternal ice and snow, man can commune with the God of Nature in the hushed stillness that brings awe, but not fear, to the soul of the intrepid explorer, and there he receives the inspiration that spurs him onward in his search for the great unknown!

This, gentlemen, is Dr. Nansen, the guest whom we delight to honor, who among Arctic explorers is "the noblest Roman of them all."

PROF. ANGELO HEILPRIN:

Mr. President, Ladies and Gentlemen :—I was asked to speak this afternoon, and inasmuch as my resources in Arctic exploration are extremely limited, it is doubtless expected of me to say something on the scientific aspect of the subject, something of what remains to be done and something that has been done.

The question of the existing and past relations of the land and

water areas in the far north is an exceedingly interesting one to the geologist. I have given it a considerable amount of attention, but have arrived at no absolute conclusion to which I should like to commit myself at present. For some months past I have been engaged in the preparation of a geological map of Arctica, more particularly with reference to the results obtained by recent explorations. It is hardly necessary for me to state with what expectancy we are looking forward to the publication of the minute geological details which have been obtained by Dr. Nansen.

As geologists, we have gone sufficiently far to be able to state certain facts. Perhaps the most important of these is the very strong likelihood that, where we find to-day the deep ocean discovered by Dr. Nansen in place of the shallow sea that was thought to exist in the far north, its place was at a period not so very remote covered by land, and instead of a polar sea we had once a polar continent. Dr. Nansen has given to us very conclusive evidence as to the condition of Siberia at the not very remote period when in the general temperate regions of the north we had glaciers running down different mountain slopes, extending to the lower valleys, cutting out the fjords and valleys in the Scandinavian peninsula, like those which we to-day find in Greenland. Since that time, not more perhaps than fifty, seventy, or a hundred thousand years ago, the condition of the country has entirely changed, and changed to such an extent as to have deceived the geologists into the belief that there never was a glacial period touching the Siberian frontier. The discovery made by Dr. Nansen, and still earlier that of the Russian traveler and geologist, Baron Von Toll, who seemingly found a fragment of the old glacial ice existing to-day, and in addition the remains of animals, such as the tiger and rhinoceros, in the deposits of the New Siberian Islands, speak conclusively of great changes of climate and of oceanic configuration.

One great pleasure I experienced on the comparatively small venture I made in the north was in searching in the deposits of Atanekerdluk, Greenland, in approximately latitude 70° N., for the remains of old foresters, the history of a forest of warm temperate aspect, with trunks and leaves indicating a growth largely identical with or similar to that found to-day in Japan, and in localities where the redwood grows in the United States, and where we have poplars, elms, maples and oaks. The dimensions of the trees measured perhaps a hundred feet or more in height; to-day

the full height of vegetation of the same region is measured by six, eight and ten inches.

The evidence appears conclusive to my mind that we had the whole northern part of this tract of the world covered by a land-mass uniting Greenland not only with Spitzbergen but also with Franz-Josef Land and northern Siberia. Dr. Nansen, I believe, gives the best evidence for assuming that Franz-Josef Land is merely a fragment of what was once united with Spitzbergen; and if we had this connection it is practically certain that its relations were continental. What the result of such continental association may have been geologists have not yet been able to determine, but it will be one of the objects for explorers to make clear to us in the future.

I think it was the Austrian geologist, Prof. Eduard Suess, who first clearly pointed out the enormous changes that are taking place on the face of the earth through downward breakages, and that even the Atlantic ocean is but a depression of a comparatively recent date (of course from a geological point of view). It may not have been in existence more than 200,000 years, possibly for one or two million years. In the Arctic regions we have evidence that what is now water was once land, not very many thousands of years ago. A second proposition brought out by Dr. Nansen in reference to the relation that Bering Strait bears to the geology and geography of the region of land to the north, points to its having been opened in comparatively recent times, and that breakages are taking place to-day we have the best of evidence. The eastern remnants of the old Asiatic connection, which at one time extended to the outlying islands, are monuments of this form of destruction.

This largely indicates the direction in which to look for the solution of the problems that the results which Dr. Nansen has given to us have raised. Scientific expeditions have been fitted out from New York to explore that very Asiatic tract for further evidences of these breakages. We know, too, that the foremost explorer of this city—I refer to Lieut. Peary—is preparing for an expedition to penetrate into the solitudes of the northernmost part of Greenland and of the regions beyond; and we have learned from recent reports that Capt. Sverdrup is at the present moment preparing for another exploration of the far north to supplement the brilliant results of Nansen.

It is not my intention to detain you longer, and I will only

express the hope that expeditions of this kind may continue to be sent out until the entire northern tract is known to us in exactly the way that much of it has been made known by Dr. Nansen.

Stated Meeting, November 5, 1897.

Vice-President PEPPER in the Chair.

Present, 28 members.

Mr. Theodore N. Ely and Mr. Richard H. Sanders, newly elected members, were presented to the Chair, and took their seats in the Society.

Acknowledgments of election to membership were read from Mr. George Wharton Pepper, Commodore Melville, Mr. Gregory B. Keen, Mr. George Vaux, Jr., Hon. Wayne MacVeagh, Mr. John C. Smock, Hon. Grover Cleveland, Prof. William Libbey, Capt. Alfred T. Mahan, Prof. Woodrow Wilson, Dr. George A. Piersol, Prof. Lightner Witmer, Prof. James M. Baldwin, Mr. Richard H. Sanders, Mr. James S. deBenneville, Prof. Henry M. Howe, Mr. James B. Leonard, Prof. Edward H. Williams, Prof. H. Morse Stephens, Mr. William Tatham, Mr. Clarence B. Moore, Mr. Charles R. Hildeburn.

Donations to the Library and Cabinet were reported, and thanks were ordered for them.

The decease of the following members was announced :

Prof. James Ellis Humphrey, of the Johns Hopkins University, on August 17, 1897, at Jamaica, W. I.

Justin Winsor, LL.D., Librarian of Harvard College and President of the American Library Association, at Cambridge, on October 26, 1897, æt. 86.

John Sartain, at Philadelphia, on October 25, 1897, æt. 89.

The Society resolved itself into the Committee of the Whole, and proceeded to the consideration of the proposed amendments to the Laws.

The Society adjourned until Wednesday evening, November 10, at 8 o'clock.